REGENERATIVE HEAT EXCHANGER

BACKGROUND OF THE INVENTION

1. The Prior Art

According to the new 1995 Heat Preservation Ordinance, the component of ventilation energy in buildings amounts to up to 70% of the heating energy consumed. If ventilation heat could be effectively recovered, it would be possible in the Federal Republic of Germany to save approximately 15 million tons of heating oil annually.

SUMMARY OF THE INVENTION

The goal of the present invention was to develop a ventilation system with very high recovery of heat that can be largely employed by anyone in order to permit the above savings.

The objective was that such a system should be capable of satisfying to the highest possible degree all or most wishes of users with respect to ventilation, i.e., for operation during the winter it should be possible to feed fresh air into a room

warm, and during the summer to admit fresh air into a room cooled. Furthermore, the fresh air should be filterable to an adequate degree. In addition, it should be possible during the summer months to feed fresh air into a room in a wetted state, but not in the course of the summer season.

Furthermore, it was necessary to expect from such a ventilation system that it should be capable of offering capacities that no longer that windows have to be opened in the conventional way, so that a high potential of heat recovery can be efficiently realized.

Energetic as well as practical considerations led in any case to a decentralized and ductless ventilation system that has to be designed in such a way that it can be installed in existing windowpanes also later, as a normal solution. It is possible only then to assure that such a ventilation system as a whole can be designed at such favorable cost that it is even economically superior to conventional window ventilation, so that the goal can be realized in this regard as well.

In solving the problems on hand it has been found that a

part of the problem that appeared to be difficult to solve in the foreground, namely recovery of heat of, for example 90%, was small in comparison to the other difficulties that arose in this connection.

The actual problems lie in user acceptance. Viewed under this aspect, and assuming that the system is installed in windows as mentioned above, ideal properties of the equipment viewed under the aspect of the user can be approximately described as follows:

The equipment has to be available at low cost; it should be invisible and as small as possible as well as maintenance-free; it should have a longer service life, and it should be inaudible; furthermore, it should not cause any draft and its power consumption should be very low.

It is attempted according to the invention, at least to start with, to satisfy said eight extreme requirements which the user wishes to have satisfied.

Owing to the small dimensions, window installation, high

recovery of heat, low energy requirement of the equipment, relatively high freedom from maintenance, and the long useful life, it was possible to satisfy said requirements for the use at least in the medium term.

Most elements can be made transparent with the clarity of glass, so that high transparency is achieved. The heat exchanger construction according to German patent application P 42 41 984, which permits low structural depth in the direction of flow-through, and which may be transparent within the interior region of the drum of the heat exchanger, contributes to such [translarency] transparency significantly.

A construction as known from the state of the art according to P 42 41 984 permits us, on the one hand, to come close to the limit of which is possible, theoretically speaking. The actual structural size is, of course, subject to natural limits, which are determined by the drive of the heat exchanger drum, the quality in terms of noise, the degree of efficiency, and the structural size of the ventilators employed. By partly exploiting the interior of the drum for accommodating ventilators, in association with elements shaping

the flow accordingly, it is possible to keep the axial structural size short as well, so that window installation is made possible without any substantially protruding components.

According to the invention, no wearing elements are employed in the construction. All seals employed for sealing off moving components are designed in the form of high-precision gap seals. As opposed to P 42 41 984, the drum of the heat exchanger is supported magnetically instead of by running wheels. This special type of bearing design for both the magnetic and the central bearings ensues an extremely long useful life expectancy, on the one hand, and very simple handling in cleaning operations and the possibility of omitting a separate drum drive and the drum speed control associated with the latter on the other.

This makes the torque of the drum drive so low that even the twist rotating the exhaust flow of the axial fresh-air ventilator is easily capable of supplying said torque.

Said twist can be exploited in three ways: first for overcoming the frictional torque and, furthermore, for

overcoming the torque of the exhaust air current: the exhaust air is provided with a twist according to the rotational speed of the heat exchanger as it passes through the latter. Said twist so applied to the exhaust air slows down the rotation. Finally, the following is accomplished for automatically adapting the rotational speed of the rotor to the through-put of air: based on a defined operating condition, which can be characterized by the instantaneous quantities of air and by a defined rotational speed, i.e., the state of equilibrium between the driving moment and the braking moment, a higher driving torque is required for the fresh-air ventilator when both air quantities are increased.

Such higher driving torque is now available for the drive of the drum. This accelerates the rotation of the drum until the moment of the exhaust air – which is now increasing as well is again as great as the driving torque. The natural rotational speed is fixed for the given dimension of the drum when selecting a defined operating condition and a defined ventilator, at least if no extra twist or spin is generated by an additional baffle element, which, however, would be possible, but is not needed. The required thermal capacity

(storage capacity) of the heat exchanger is thus fixed even if further marginal conditions are taken into account. This then leads to the thickness required for the heat exchanger and thus also to the size of the network structure.

The useful life is preliminarily limited primarily by the oil of the journal bearings of the ventilators. Said bearings are therefore maintained as cold as possible, and heating of said bearings by the motor is kept low through high efficiency. Since maintenance work is nonetheless required here after about 10 to 15 years, and costly customer service is to be avoided, the rotor and its bearing are made into a pluggable unit, which is axially fixed by the stator of the motor of the outer rotor only by means of the permanent magnets, the latter being present in said unit, to begin with. Said unit can then be replaced by the user as required, within seconds without any tools. Furthermore, this makes it easy to clean the race and the rotor itself. The central bearing, which is preferably a small ball bearing, can be easily replaced by the user as well as required. The useful life of said bearing is in the order of magnitude of 30 years owing to very low load and low temperatures. When the heat exchanger has to be cleaned, the

central bearing remains in the cros— bar, so that said bearing is never loaded with moisture.

Due to the introduction of an aerodynamic rotor drive it is possible to dispense with an additional source of noise, which may be dominating mainly if the noise levels are low. Furthermore, the noise sources can be reduced further by means of twist-absorbing elements upstream of the intake openings of the ventilators and through careful designing of the inlet nozzles, thin bridges spaced farther away from the rotor, diffusers reducing the load received, as well as through measures reducing the physical sound. The heat exchanger itself finally acts as an effective sound damper through the two perforated sheet metal plates and the heat—transferring network. Furthermore, the interior space of the drum still leaves space that can be filled with sound absorbers at least to some extent, naturally at the expense of losing some transparency. By introducing the twist-absorbing flow rectifiers it is possible to re-regulate the flow in spite of confined space conditions. Last but not least, the ventilators and the heat exchanger are coordinated with each other in the operating range that is optimal with respect to noise

suppression.

The largest possible cross section of outflow is obtained by omitting a housing. The residual rate of flow is eliminated very quickly due to the radial outflow. In order to prevent upward flow into the zone where the air is sucked off and thus a partial short-circuiting of the flow, provision is made for a flow rectifier on the outlet, which is fixed magnetically as well (on the window installation ring). Said flow rectifier eliminates at the same time the twist. The resulting flow will then practically gradually drop downwardly, so that this ventilation system can practically act like an advantageous source air system (the in flowing fresh air is always slightly colder than the room air even in the summer because cooling is possible with this device as well).

All measures serving for reducing the noise simultaneously act as measures reducing the power input. Collectorless dc motors are employed.

After the heat exchanger has been removed it can be easily cleaned in a bathtub with cold water and detergent by rolling

it back and forth. Intensive cleaning with salt water can be carried out semi–annually in the same way. Since the device can be installed in the windowpane it is accessible from all sides and it thus can be cleaned completely, including the rotors and the race. The region (acrylic glass) disposed between the ventilators, which is normally not accessible but nonetheless needs to be connected with the air (change in volume of the air at ambient temperatures of –30°C to +40°C, pressures), and which is therefore exposed to dust, is supplied with dedusted and dehumidified air via one single controllable opening.

By making the transparent ventilator mountings from acrylic glass the heat exchanger is supplied not only with the optical advantages but at the same time also with the bacteria- and fungus-destroying effects of the UV–component of the sunlight. Furthermore, the heat exchanger can be supplied in the off–air zone on the room side with ozone via two axial wires conducting high voltage. Said ozone effectively liberates the fabric of the heat exchanger from odorous substances and is directly discharged into the outside air. Since the heat exchanger is moving under the wires it is cleaned on its entire surface. The local ozone concentration may be very high,

whereas the concentration in the exhaust air itself may be low. No ozone is discharged into the room air itself.

Cleaning and maintenance work can be carried out practically without tools because all elements are fixed magnetically.

It is desirable in the winter to recover also a major portion of the off-air moisture. This, however, it not desirable during the summer. One possibility would be to employ two drums with different network materials: the one material with absorbing properties, e.g. Perlon, and the other with neutral properties, e.g. polyethylene.

Evaporation cooling in association with the capillary effect of fabrics for water transport is exploited for cooling. Before it is received in the heat exchanger, the exhaust air is sucked through a wet cotton fabric with a structure similar to the one of the heat exchanger network. A bandaging fabric was found to be usable for this purpose. Approximately four layers suffice for about 98% air wetting. When passing through said fabric, the exhaust air is practically cooled to the cooling

limit temperature. The cold exhaust air is then received in the heat exchanger and cools the latter as well. The fresh air is then cooled in the course of said passage almost to said temperature as well without absorbing any additional moisture. On the average, the fresh air is received in the room about 6^{0}C colder than the exhaust air.

The fabric is supplied with water as follows:

Via a float—controlled water valve, which is directly supplied with the pressurized water of the water mains via a thin hose, the water level is maintained approximately constant in a plurality of U-shaped ducts, which extend parallel with each other on the same level, and which communicate with one another.

The U—shaped ducts are closed at their face—side ends. The U—shaped ducts are framed in a flat horizontal frame in such a way that the upper surface of the frame is finished off flush with the U—shaped ducts, which are open at the top, whereby the ends of the U-shaped ducts still feed about 10 mm into the frame. A multilayered cotton fabric cut to a matching size can

now be flatly placed on said frame.

A fitting bar is inserted in the locations where the ducts are situated, said bar immersing the fabric in the water-filled ducts. The intermediate (clear) spacing of the U-ducts is selected in such a way that the capillary water transport capacity corresponds with the evaporation possibility (about 4 to 6 cm). This evaporation frame, which can be placed on the window ring in connection with a collecting and approximately sealing air duct construction, assures easy cleaning of the evaporating cotton fabric. Cooling with normal nondecalcified tap water is possible for this reason as well. Excessive interfering lime deposits can be removed from the fabric with vinegar.

Placing the fabric in position is very easy and the tightness of the joint between the fabric and the frame is fully assured. The size of the frame is selected in such a way that the loss of flow pressure amounts to only about 1 to 3 Pa. It is, therefore, not necessary that the air duct around the rotating drum is absolutely tight. Gap seals suffice fully.

The advantage of the described arrangement is that the cooling can be operated without extraneous energy except for the minor additional pressure loss; that such cooling can operate with minimal amounts of water; and that no further control is required. Furthermore, it is advantageous that a hose with less than 1 rrtm inside width can be employed because of the small amounts of water required for the water supply. Such a hose can be installed quickly in a way in which it is almost invisible.

The construction is preferably manufactured from transparent plastic.

The described evaporation frame is preferably provided with a folded design, so that the required cross section of flow is maintained with a small structural width.

The device has to operate flawlessly in a temperature range of from -30°C to +40°C., whereby parts of the device are maintained at the level of room temperature irrespective of the outside temperature, whereas other parts simultaneously assume the outside temperature.

So as to assure user acceptance and in light of the windowpane installation, the device has to be transparent, small and quiet, but nonetheless offer high efficiency and high ventilation capacity (structural size of the device about 380 mm at 200 mm structural depth on the room side, and 80 to 200 m^3/h fresh air at $\geq$ 90%).

This means that very high temperature variations and thermal expansions have to be expected within the device.

With the desired high efficiency of about 90% and the small structural size it is difficult under the specified marginal conditions to maintain operationally safe sealing over said temperature range.

Sealing is particularly critical between the rotor and the installation ring because the volume of air flowing through here is not participating in the heat exchange. If 1% of the air volume flows through there, the efficiency is already reduced by about 1% as well, i.e., the quality of heat transfer actually needs to amount to 91% instead of 90%. This, in turn, means that the size of the heat exchanger should be increased

by 10%. The latter value is even higher because other factors reducing efficiency play a role here as well. This would hardly be significant with a device with less efficiency; however, it becomes important with a device with high efficiency. Therefore, with a high-efficiency device it is unimportant for the consumption of ventilation energy whether much or little or no ventilation takes place, i.e., such a device no longer requires controlling of the air volume or monitoring of the quality of the air. However, such controls are still useful and needed with a low-efficiency device. Certain components of the device, namely all surfaces on the room side, are exposed to the room temperature and to the humidity of the room air. The inside surfaces of the device all are exposed to the conditions of the outside air.

If no special measures are implemented, phenomena of condensation and formation of ice (icing) may occur on the surfaces on the room side and pose problems for the weak aerodynamic drive.

Since the critical sealing gap addressed above should be about 0.3 mm or smaller, the overall construction is required

to satisfy high requirements with respect to manufacturing quality, installation quality, storage quality etc. The implemented measures can be divided in two groups as follows:

One group comprises measures that are required for the actual function of the device, and the other group serves for reducing noise and for rendering the equipment maintenance-friendly.

(1) Aerodynamic drive of the heat exchanger drum

[i]

Use is made of the turbulence naturally imparted on the flow of air by the fresh-air, axial-design ventilator. This rotation of the air is slowed down by the heat exchanger network because the latter acts like the grid of a turbine. The heat exchanger thus is driven by the rotary pulse. This principle is, of course, applicable to other regenerative heat exchangers with rotary drives as well if provision is made for smoothly running bearings. Furthermore, said principle can be employed for completely passive heat exchanger components if the air is provided with a circumferential component by implementing a static, twist-generating measure. Such a rotary drive, moreover, offers the advantage that the rotational speed

automatically adapts itself to the air volume. Since the driving torque is very low, there is the risk that insects, for example, sucked into the lateral sealing gaps, may shut down the drive. This, however can be easily counteracted by making the gyrating mass of the rotor adequately large and the intake honeycomb sufficiently small (3 mm suffices). In any case, no shutdown of the rotor was observed in the course of two years, which means said drive was found to be extraordinarily reliable

(2) Omission of complete sealing between the fresh air and the off-air chamber on the longitudinal bars

It is not possible, to begin with, to prevent air from being forced from the fresh—air zone into the off—air zone regardless of which heat—transferring construction is being employed. With a closed—cell type of construction, air is transferred at least by the rotational motion. With an open cell type of design, as it is present in the last analysis in the form of the network employed in the present case, air flows in the circumferential direction from the chamber with high pressure into the chamber with lower pressure. This loss can be minimized with an adequately long flow path, whereby a genuine

optimum actually exists in this connection if one takes into consideration that the length of the sealing path has to be deducted from the effective length (circumference) of the heat exchanger. Therefore, provision is made only for a single gap seal, the gap measure of which is limited only by the manufacturing quality and possible rotor movements. With the specified size of the device, the gap measure comes to around 0.5 mm and the length of the sealing gap to around 35 mm. The loss through the gap basically conditions only a corresponding extra delivery of the ventilators, but no reduction in the efficiency. It is advantageous in connection with this measure that it makes the aerodynamic rotary drive possible, to begin with, and that the seal, furthermore, operates free of wear.

(3) Design of the longitudinal bars as control elements for admitting air to the heat exchanger.

Different local amounts of air are admitted into the heat exchanger at the top and at the bottom. The reason for this has to be seen in the fact that the flow of fresh air, for example, has a higher dynamic pressure component near the front pane than near the installation ring. Different amounts of air are

therefore admitted into the heat exchanger depending on the axial position. Similar processes take place on the off-air side. It is possible to achieve that the amounts of air are identical for fresh air and off-air in one axial position by designing the longitudinal bars accordingly, without losing heat exchanger surface area for this purpose.

However, the exact design of the cross bars can be determined only after measuring the local axial degrees of efficiency.

(4) Use of glass for the drum termination on the room side

The temperature variations cause the pane to vault (bimetal effect). Glass, as opposed to a conceivable plastic material, has a 5-times higher thermal conductivity and about a 7-times lower thermal expansion, which overall ensues 35-times less vaulting. Arching would reduce the critical sealing gap and cause the drum to grind on the pane because the drum is axially fixed from the pane side.

(5) Axial fixation of the drum in the plane of the glass pane

According to the state of the art it is viewed as being advantageous if the drum is axially fixed near the critical sealing gap and if the central bearing is freely displaceable axially. The reasons for this are the above-mentioned vaulting of the pane and the expansion of the longitudinal bars. In deviation of the above, it is advantageous in the case of a magnetic bearing if the drum is axially fixed in the opposite way, i.e., if this positioning is shifted to the central bearing, with the effect that the support of the magnet can be simply realized in an uncontrolled way with permanent magnets and that such support is inherently stable. For compensating the thermal changes in the length of the longitudinal bars and the residual vaulting of the pane, provision is made for a compensating device that is dependent upon the outside temperature (plastic tube with high coefficient of expansion). Said compensating device displaces the central bearing axially relative to the position of the cross bar.

(6) Magnetic bearing

The magnetic bearing is arranged on the face side of the

open end of the drum, acting there practically axially, but it is nonetheless capable of absorbing radial forces. This is accomplished by making the diameter of the magnetic counter system arranged in the installation ring about 1 mm smaller. The drum is capable of performing only tilting movements about the central bearing within a cone, whereby the tip of the latter is located in the central bearing. With correct dimensioning of the sealing gap and of the aforementioned difference in diameters, a stable support is accomplished, in that when the drum executes a tilting motion downwardly, the magnets approach one another at the top, causing the braking forces to increase and thus to counteract the tilting movement. The same takes place in the reversed sense on the opposite side (at the bottom). With the same tilting movement, the magnets move away from each other and the counteracting overall torque around the central point of rotation is increased further. The magnetic countersupport in the lower region actually has an effect reducing the bearing capacity, however, the entire magnetic bearing is made considerably stiffer in this way and less sensitive to temperature—dependent variations of the magnetic properties (about 10%). The operating load has to be taken into account as well, said load being composed of the

rotor weight (27 N in the present case) and the variable pressure in the feed air and in the off—air chambers (0 to 9 N in the present case). The support has to be adequately safe under all of said conditions, and the critical sealing gap may change only by approximately 0.1 mm.

(7) Perforated sheet metal plate

Provision is made for a second outer perforated sheet metal plate, which is in thermal contact with the face-side rings, as well as for a first perforated sheet metal plate, on which the heat exchanger is wound. Furthermore, provision is made that said first plate is thermally and mechanically decoupled from the face-side rings. The primary function of the second perforated sheet metal plate is to maintain the face—side rings at room temperature in order to prevent phenomena of condensation and formation of ice on the magnetic bearing. The perforated sheet metal plate acts as a relatively good heat exchanger and is practically at room temperature. The rings connected therewith and the face—side magnetic bearing are maintained at room temperature in this way as well. If the stationary part of the magnetic bearing is thermally insulated

by the installation ring as well, no problems at all will arise that could be caused by condensation and icing. Since the outer perforated sheet metal plate is in thermal contact with the rings on the face side, it has a supporting function as well, as opposed to the first inner perforated sheet metal plate. The latter has to be kept insulated against the face-side rings because a medium temperature between the room temperature and the outside temperature would otherwise adjust on the rings. Such thermal insulation is realized via resilient silicone inserts, which can compensate also the variations in length between the inner and the outer perforated sheet metal plates. The glass pane is maintained insulated in a similar way for the same reasons. In the ideal case, the glass pane could be vacuum-insulated unit, if possible.

(8) Center-point positioning of the central bearing on the cross bar

It is important for the function that the central bearing is seated exactly in the center relative to the magnetic bearing because any out-of-center positioning would influence the critical sealing gap. An adjustment possibility would be

conceivable for this purpose. A simpler solution, which directly assures high precision in spite of the assembly of various components, consists in producing all participating components on turning lathes and to exploit the natural rotation symmetry. The installation ring, on which the longitudinal bars have to be mounted, is provided therefore with grooves on the inner circumference, such grooves being similar to grooves of a thread. The longitudinal bars are cut from a cylinder jacket, which is provided with such grooves on the circumference and on one face side in a corresponding axial position as well. The cross bar is in turn provided with such grooves on the face side and drilled open directly centrally. Now, when the components are assembled, whereby only one single screw is required for each connection, everything is set up correctly: the longitudinal bars are set at a right angle relative to the installation ring and the central bore is always located in the center irrespective of where the screw holes are exactly positioned, and all components are joined with each other with adequate rigidity in a sufficiently fixed manner.

(9) Fixing of the drum and axial adjustment of the critical

gap; construction of the central bearing

The central deep-groove ball bearing is solidly connected with a steel axle, which is loosely plugged through the bore of the cross bar and which supports a thread at the other end, said thread being axially fixed in a plastic piece supporting a thread as well. When the plastic piece becomes colder and contracts, the ball bearing moves away from the other side of the cross bar. This is necessary because the longitudinal bars become simultaneously shorter, whereas the outer perforated sheet metal plate remains unchanged with respect to its length (room temperature), and the sealing gap would therefore become smaller. This is compensated by the axial displacement of the ball bearing. With its outer ring, the ball bearing is solidly seated in a part which, on the outside, supports a thread as well, and which is provided with an axial stop means. The drum can be screwed in on said thread up to the stop means. A borehole is provided centrally, through which the central axle can be adjusted axially with a screw driver, and thus the sealing gap (all participating components are made of aluminum; the coefficient of thermal expansion of plastic is 3 to 8 times higher than the one of aluminum). When the heat exchanger is

dismantled, the ball bearing remains on the cross bar, so that the heat exchanger can be cleaned without problems with water and no screw can be displaced by the user because the latter remains on the ball bearing. The flange, which has an inside thread, is elastically joined by gluing with the glass pane in the center toward the open face side.

(10) Separation wall; exploitation of the interior space

All foreign matter getting into the device is deposited the separation wall. For this reason, the separation wall is magnetically fixed and can be removed from the bottom. The magnetic fixation, which extends all around, makes it easily possible to install the separation wall permanently sealed. The magnetic strips are arranged in this connection in such a way that they are capable of sliding on each other in a sealing manner. If extreme requirements need to be satisfied with respect to noise, the interior space can be exploited further for sound—absorbing measures because not much consideration has to be shown to the current of air streaming into the ventilators. This is made possible by the honeycomb rectifiers arranged upstream of the intake openings.

(11) Mounting of the plexiglass dishes on the installation

Because of the differences in thermal expansion, this connection is established via elastic intermediate elements. Since the zone between the plexiglass dishes - which support also the ventilators - will no longer be accessible after the installation has been completed, which means that said zone cannot be cleaned later, admission of dust and moisture has to be prevented (for the sake of preserving transparency!).

If said zone were kept completely airtight, problems would arise due to changes in pressure at temperature changes. For this reason, provision is made for a controlled opening which, via a filter, permits air exchange. Since air will flow in only when the temperature drops, and air will flow out only when the temperature rises, the moisture filter is capable of self-regeneration. The arrangement in the fresh-air zone by nature assures in this connection the lowest air humidity; regeneration can be supported by [inciding] including sun radiation. If need be, the insulating glass intermediate space can be supplied with said dedusted and dehumidified air as well via a very small borehole on the installation ring, so that in the

presence of wind gusts, the insulating glass pane disposed on the inside is still capable of providing support.

(12) Fresh—air outlet zone on the room side

Since the current of fresh air has, in addition to the radial flow component, also a tangential flow component, the flow of air has to be prevented from being sucked upwardly by a flow—shaping measure. In the simplest case, this may be a short apron in the region where the heat exchanger changes from the fresh—air zone into the exhaust air zone. The fresh air is deflected downwardly by said measure. A honeycomb-like grid is conceivable as well. Also, the fresh air could be guided into the room in the form of a jet. The flow-shaping means are magnetically retained by the installation ring.

(13) Noise—reducing measures

The basic idea in this connection is to prevent noise from developing, to begin with, because existing noise can be eliminated again only with voluminous expenditure. In the present construction, the ventilator is the principal source of noise. Three further individual sources of noise can be found in the ventilator, namely air vortices, motor noise and

vibrations.

Based on air vortices, the first measure, therefore, is to depart from the usual short and small type of ventilator construction. The flow requires space so as to be able to arrange itself smoothly. Therefore, provision is made for an inlet nozzle dimensioned in a sufficient size, which accelerates the flow to the rotor inflow speed without radial jumps. Good results are obtained in this connection even with an elliptically shaped nozzle, which starts at about 1.37 times the diameter of the rotor, and which has a structural depth of about 0.24 times the diameter of the rotor. These values and the shape are specified only by way of example in order to give some idea about the approximate space requirement. A honeycomb-shaped flow rectifier with a honeycomb depth of about 3 mm and a diameter of about 3 mm is connected upstream of the nozzle. Said rectifier has a semispherical shape or the form of a basket in order to be capable of carrying out its function at low flow rates and pressure losses. The flow is very effectively shaped by such a flow rectifier in spite of its short length of flow-through. The basket is sunk inserted in a groove around the nozzle and fixed magnetically so that the air

can flow into the nozzle without any threshold. The inlet into a diffuser starts downstream of the rotor. The inlet consists in a transition radius of about the diameter of the rotor and constantly feeds into a straight diffuser. The large transition radius prevents premature rupture of the flow because the direction of flow is not changed abruptly.

A short tube serving as a surge diffuser is connected downstream of the constant diffuser, said surge diffuser also preventing off-air from being sucked again into the exhaust air outlet. Said tube, too, is fixed magnetically. The overall structural length of such a ventilator [amouts] amounts to about 1.5 times the diameter of the rotor. Only about half thereof protrudes due to exploitation of the space within the heat exchanger drum.

The struts holding the ventilator motor in the race are arranged far removed from the rotor on the end of the diffuser inlet. In order to keep flow losses and sound noise low, the ventilator drive is provided with a counterweight which permits suspending the unit in its point of gravity. This, in turn, makes it possible to design the holding struts very thin. The

holding struts are used at the same time for feeding the current for the low voltage.

The driving unit itself consists of the rotor, the bearings, the motor stator with electronics, the bearing tube, the counterweight, the bearing tube casing, the vibration decoupling and the adjusting device.

The bearing (single-part slide bearing) and the rotor jointly form one unit, which is kept together with a safety ring. Said unit can be axially plugged into the bearing tube and basically forms a slide—supported slide bearing. Of course, it is understood that the bore of the bearing tube and the outside diameter of the slide bearing may have only very little clearance, for which reason these fitted components are lubricated with a very viscous grease. The motor stator is plugged onto the bearing tube as well and fixed in defined points with silicone, the reason for the latter being that a new motor stator can be easily mounted again when needed. The stator receives its current from the struts via plug connections.

The bearing tube, which is provided on the end with a counterweight, is retained by two axial, radial and rotation-elastic silicone disks, which are symmetrically arranged relative to the center of gravity.

The silicone disks themselves are radially displaceably supported in the housing of the drive. Their positions can be fixed by axial clamping via a thread and a force-transmitting spacer piece.

The purpose of said construction is to suspend the ventilator very softly and to make it possible to correct any setting phenomena of the damping elements also at a later time (insulation against vibration).

Such a construction permits fixing all possible corrections (radial as well as angular corrections) with one single screw.

Said measures are required because the rotor has to run in the race with very tight clearance for noise and capacity reasons. The race itself is softly connected with the inlet

nozzle and the diffuser as well, in a manner such that the marginal flow is disturbed only in minor ways.

This is accomplished by connecting the components by means of a U–shaped silicone ring which, with its open side, points at the axis of rotation. Such soft connection is required also because of the difference in thermal expansion (acrylic glass versus aluminum). This double insulation is required taking into account that the plexiglass dish acts like the diaphragm of a loudspeaker. Since the weight of the ventilator construction is relatively high and the U–rings have to be very soft, it may be necessary to compensate part of the weight via an elastic element mounted on the installation ring.

(14) Anti–turbulence honeycomb in the off–air zone directly downstream of the heat exchanger.

Since the exhaust air is provided with a twisting motion after passing through the heat exchanger, such twist is largely eliminated in a first honeycomb grid. The [second] second honeycomb grid located directly upstream of the exhaust air ventilator then absorbs the residual twist. Only both measures jointly effect

the desired noise—reducing elimination of the twist.

For achieving wetting of the air passing through the heat exchanger, provision is preferably made that the heat exchanger is immersed in a calcium chloride solution, so that it is soaked with calcium chloride when it is removed from said solution, which is capable of absorbing water vapor.

The recovery of moisture can be adjusted through selection of the concentration of the calcium chloride solution.

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BRIEF DESCRIPTION OF THE DRAWINGS

The drawing serves for explaining the invention in greater detail. In the drawing,

FIG. 1 is a schematic section through the entire heat exchanger arrangement.

FIG. 2 is an enlarged representation of the region where the ventilator is suspended.

FIG. 3 is a sectional representation of the magnet support.

FIG. 4 is an enlarged sectional representation of the region of the sealing gap.

FIG. 5 is a sectional representation of the central bearing including the temperature compensation provided for; and

FIG. 6 is an enlarged sectional representation of the region of the front ring.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Turning now in detail to the drawings, FIG. 1 shows a regenerative counterflow heat exchanger 10 for gaseous media, in particular an air heat exchanger for ventilating rooms in buildings, with a heat exchanger drum 12 receiving in an alternating sequence the flow of the heat-emitting and heat-absorbing gaseous medium. The drum 12 has an open end 14 forming one face side 16. Drum 12 is rotatably supported in a bearing 18 and having an active surface consisting of a multilayered network 20. There are at least one ventilator 22 which produces a flow of feed air and one ventilator 24 which

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produces a flow of exhaust air. The heat exchanger drum 12 substantially forms a fixed outer limitation of the device and the bearing 18 is designed as a combination of a mechanical bearing and a magnetic bearing. The magnetic bearing is arranged on the face side 16 of the open end 14 of the heat exchanger drum 12 and the mechanical bearing 26 is designed with a central bearing 28 on which the heat exchanger drum 12 is fixed. This is fixed in a way such that in the mounted condition, its drum axle is substantially capable of executing only tilting movements within a cone, with the tip of the cone being disposed in the central bearing.

The central bearing 28 is connected with a stator 30 in a fixed manner, as shown in FIG. 2. The stator 30 is designed with a stationary ring 32. The magnetic bearing 18 is formed only with permanent magnets 34. Provision is made for a partial magnetic system 34 connected with the rotatable heat exchanger drum, the magnetizing device of the partial magnetic system being arranged parallel with the axle of the drum. Provision is made for a partial magnetic system 34, which system is stationary relative to the heat exchanger drum 12 and is connected with the stator 30. The stationary part of the

magnetic system 34 has a diameter slightly smaller than the diameter of the partial magnetic system 36 connected with the rotatable heat exchanger drum, as shown in FIG. 2.

The magnetic bearing 34 is formed with a main magnetic bearing 38 in the region of an upper half 40 of the stator 30, and with an oppositely acting and thus the bearing capacity-reducing second magnetic bearing 42 in the region of a lower half 44 of the stator 30. The second magnetic bearing 42 complementing the main magnetic bearing 38, as shown in FIG. 3. The magnetic bearing at the same time satisfies a sealing function.

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The central bearing 28 is connected with a cross bar 46, and the cross bar is connected in a fixed way with two longitudinal bars 48 connected in a fixed way with the stator 30. The longitudinal bars 48 are connected with the stator 30 in such a way that any inaccuracy in the angular position on an axis disposed perpendicular to the axis of the drum has no influence on the center point of the central bearing 28. The cross bar 46 and/or the longitudinal bars 48 are components at least partly produced cylindrical in shape. The heat exchanger

drum 12 has a means 50 for adjusting its axial position, whereby said means 50 is designed in such a way that a loss–causing sealing gap is adjustable between the heat exchanger drum 12 and the stator 30 from the outside as shown in FIG. 5. The central bearing 28 is axially displaceable as shown in FIG. 5.

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Provision is made for a compensating device 52 for compensating the thermal change in the length of the longitudinal bars 48. The compensating device 52 is designed in such a way that a change in the outside temperature leads to an axial displacement of the central bearing relative to the cross bar 46. The heat exchanger drum has a closed face side 54 and it is axially fixable from this face side 54 by magnetic fixation means 56. The heat exchanger drum is designed in such a way that it can be pulled off axially without obstruction. The heat exchanger drum can be put into rotation by means of a current of air provided with a twist from the feed air ventilator 22. The off–flow of an axial ventilator 24 is directly used as the current of air provided with a twist. The axial ventilator 22 blows out parallel with the axis of the drum and that the axial rotor 58 is arranged spaced from the

axis of the drum. The ventilator is designed as a feed air ventilator 22. The ventilator 22 and 24 are at least partly arranged within an inner space of the drum of the heat exchanger.

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As shown in FIG. 1, a regenerative counterflow heat exchanger 10 for gaseous media, in particular an air heat exchanger for ventilating rooms in buildings, with a heat exchanger drum 12 receiving in an alternating sequence the flow of the heat—emitting and the heat—absorbing medium, the active surface of said heat exchanger drum 12 consisting of a multilayered network 20. At least one ventilator 22 produces a flow of feed air and at least one ventilator 24 produces a flow of exhaust air. The heat exchanger drum substantially forms a fixed outer limitation of the device.

Exclusively contactless gap seals 60 are usefully employed as sealing elements. An outer perforated sheet metal plate 62 is useful in thermal contact with the face-side rings in order to maintain said rings at room temperature. A relatively "cold" inner perforated sheet metal plate 64 is usefully maintained thermally insulated. After pulling off the drum, the face—side

central bearing 28 usefully remains in the cross bar 46. A face-side closure of the drum usefully consists of a transparent material, preferably of glass 66. After releasing one single centrally arranged fixing device, the latter usefully remains unlosably on one of the components to be separated. Highly elastic intermediate elements 68 (FIG. 4 and FIG. 6) are usefully employed for compensating thermal expansions between the glass pane 66/central bearing receptacle or outer plate 62/inner perforated sheet metal plate 64 or pane installation ring/ventilator mounting or ventilator mounting/ventilator race configurations.

Viewed in the direction of the axis of rotation, the longitudinal bars 48, which serve at the same time as sealing elements between the feed air 22 and the exhaust air 24 chambers, usefully divide the chamber circumference or the chamber lengths acted upon in the circumferential direction as required. Thus each axial chamber section is basically complementarily acted upon by the same amounts of air. The longitudinal bar 48 is usefully mounted thermally insulated on the installation ring.

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The infeed flow of the ventilators usefully takes place through a twist-absorbing element, for example through a honeycomb grid 70. After passing through the heat exchanger 12, the exhaust air usefully flows through one or a plurality of twist–absorbing elements 70. The ventilator rotors 58 including their bearings usefully form a magnetically fixed unit, which is axially removable without tools. The heat of the bearings and of the motors of the ventilators is usefully transferred via a bearing tube 72 to a counterweight 74 located in the flow of air as shown in FIG. 2. The bearing tube 72 is preferably already vibration-damped and supported in a housing. The vibration damper is preferably designed also as a sound absorber in the form of a silicone foam elastic disks 76 in order to reduce higher–frequency commutation noise.

The ventilator is usefully suspended in a race in a way such that the unit is suspended in the point of gravity and that vibrations are largely damped out in their site of origin. Thus the mounting can be designed very weak, which effects low development of noise and increased air capacity. The rotors 58 usefully run in their casings with very narrow clearance.

Flow–shaping elements 78 are usefully fixed magnetically. A flow–shaping element is usefully arranged on the blow–out side on the room side, such element preventing fresh feed air from being directly received again in the upper exhaust zone. In the simplest case, this element may be a simple apron which, with the help of the air exiting from the last 10% of the heat exchanger, deflects the residual previous air by jet effect downwardly. The exhaust air on the room side is usefully exhausted from the top, and the fresh feed air is blown downwardly. The entire region within the diameter of the heat exchanger is usefully designed largely transparent. The ventilators 22 and 24 are usefully arranged within the diameter of the heat exchanger. Both ventilators 22 and 24 are usefully arranged at the same temperature level, preferably at the level of the outside temperature.

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The wall 80 separating the chambers is usefully removable from the bottom and is preferably fixed magnetically. The wall 80 separating the chambers is usefully designed as a sound absorber. The space disposed on the inside usefully contains a flat stationary sound absorber 76 located directly upstream of the closed face side of the drum. The ventilators 22 and 24 are

usefully provided with a nozzle—like inlet, the latter being at least 1.2 times larger than the diameter of the rotor. Thus the ventilator races of the inlet nozzle and the diffuser are preferably decoupled with respect to physical sound via soft intermediate elements.

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With insulating glazings 68 and 82 in FIG. 4 and in FIG. 6, a controlled connection is usefully established between the intermediate space of the insulating glass pane 66 and the outside air. Thus the air flowing through the connection passes through a dust and moisture absorption filter 84. The filter 84 is preferably arranged in such a way that the filter 84 is heated and moisture is expelled by possible sunlight irradiation, so that the filter regenerates itself automatically. The heat exchanger is usefully installed in a window. The recovery of moisture is usefully adjustable through selection of the concentration of a calcium chloride solution.

Provision is usefully made for a passive combined ventilation element containing a static element providing the flow of air with a twist before said air flows through the heat exchanger and drives the latter without having to make

provision for a ventilator, whereby the axis of rotation preferably extends vertically. Regenerative heat exchanger having a rotating type of design, whereby the drive of the heat exchanger drum 12 is generated by a flow of air provided with a twist. Provision is usefully made for a passive, combined ventilation element containing a static element providing a flow of air with a twist before said air flows through the heat exchanger and drives the latter without having to make provision for a ventilator. The axis of rotation preferably extends vertically.

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An elastic ventilator bearing tube 72 has a mounting 86. There is also as shown in FIG. 2 an intermediate piece 88 connecting the ventilator drive and a counterweight 74 is retained by two elastic disks 76 and 90. These disks in turn being radially displaceable in a stationary housing 92 and axially jointly fixable in their positions by clamping via an intermediate piece 88.